



mA-2000
DC/TRUE RMS AC
NON-CONTACT MILLIAMMETER

Instruction Manual

NOTICE

See Page 3-1 and 3-2

for SAFETY

Instructions !

NOTICE

See Page 2-1 and 2-2

for SAFETY

Instructions 1

Table of Contents

SECTION-1 INTRODUCTION

DESCRIPTION.....	1-1
APPLICATIONS.....	1-2

SECTION-2 SPECIFICATIONS

SPECIFICATIONS.....	2-1
---------------------	-----

SECTION-3 OPERATING INSTRUCTIONS

OPERATOR SAFETY.....	3-1
OPERATING FEATURES.....	3-3
MEASUREMENT PROCEDURES.....	3-7
Probe Preparation.....	3-7
DC Current Measurements.....	3-8
Low Frequency AC Current Measurements.....	3-10
High Frequency AC Current Measurements.....	3-10
Measurement Hints.....	3-11
GENERAL MAINTENANCE.....	3-13

REGULATORY INFORMATION..... 4-1

WARRANTY.....back cover

Table of Contents

SECTION 1: INTRODUCTION	1-1
SECTION 2: GENERAL INFORMATION	2-1
SECTION 3: SPECIFICATIONS	3-1
SECTION 4: DRAWINGS	4-1
SECTION 5: MATERIALS	5-1
SECTION 6: CONSTRUCTION	6-1
SECTION 7: TESTING	7-1
SECTION 8: MAINTENANCE	8-1
SECTION 9: SAFETY	9-1
SECTION 10: APPENDICES	10-1
SECTION 11: INDEX	11-1
SECTION 12: GLOSSARY	12-1
SECTION 13: BIBLIOGRAPHY	13-1
SECTION 14: REFERENCES	14-1
SECTION 15: NOTES	15-1
SECTION 16: COMMENTS	16-1
SECTION 17: REVISIONS	17-1
SECTION 18: APPROVALS	18-1
SECTION 19: DISTRIBUTION	19-1
SECTION 20: HISTORY	20-1
SECTION 21: SUMMARY	21-1

List of Tables

Table 2-1	mA-2000 Specifications.....	2-1
-----------	-----------------------------	-----

List of Illustrations

Figure 3-1	Conductor Voltage Limit Warning	3-1
Figure 3-2	Bare Conductor Warning.....	3-2
Figure 3-3	Auxiliary Power Connection Warnings..	3-2
Figure 3-4	Product Features.....	3-3
Figure 3-5	Battery Installation and AC Adapter Connection.....	3-7
Figure 3-6	Probe Connection.....	3-8
Figure 3-7	DC Zeroing Process.....	3-9

List of Tables

Table 1-1	Physical Properties of the Polymer	1-1
Table 1-2	Physical Properties of the Polymer	1-2

List of Illustrations

Figure 1-1	Physical Properties of the Polymer	1-1
Figure 1-2	Physical Properties of the Polymer	1-2
Figure 1-3	Physical Properties of the Polymer	1-3
Figure 1-4	Physical Properties of the Polymer	1-4
Figure 1-5	Physical Properties of the Polymer	1-5
Figure 1-6	Physical Properties of the Polymer	1-6
Figure 1-7	Physical Properties of the Polymer	1-7
Figure 1-8	Physical Properties of the Polymer	1-8
Figure 1-9	Physical Properties of the Polymer	1-9
Figure 1-10	Physical Properties of the Polymer	1-10

Section 1

Introduction

DESCRIPTION

The *mA-2000* is a battery-powered, clamp-on instrument that measures dc and ac current as low as 1 mA and as high as 2000 mA, at frequencies up to 100 kHz. The *mA-2000* consists of a palm-sized meter and a detachable probe. The probe clamps around the conductor to be measured. There is no need to disconnect the conductor or make physical contact with the circuit being measured. The current-carrying conductor is surrounded by a magnetic field that is proportional to the amount of current that is flowing through it. The probe senses the magnetic field and provides a signal to the meter. The meter then translates this signal into a milliamp current value.

The probe features a unique aperture mechanism that retracts easily and closes smoothly. The probe can accommodate conductors up to 5.3 mm (0.21 in.) in diameter.

The meter operates on two standard 9 volt alkaline batteries or can be operated with an ac adapter. Two ranges can be selected (199.9 mA or 1999 mA full scale) in addition to three modes of measurement; dc, low-frequency ac or high-frequency ac. The meter contains a 3 1/2 digit display that provides dc and true rms ac readings. In addition, an analog output provides a 1 mV / mA voltage signal proportional to the current being measured. This output can be connected to a voltmeter, oscilloscope or recorder.

The meter, probe and accessories are protected between use by a sturdy carrying case.

Section 1 Introduction

Introduction

The first chapter of this book is a general introduction to the field of statistics. It covers the basic concepts and terminology of statistics, and discusses the importance of statistics in various fields of study. The chapter also introduces the reader to the different types of data and the methods used to collect and analyze them. The chapter concludes with a discussion of the role of statistics in decision-making and the importance of understanding the limitations of statistical inference.

The second chapter of this book is a general introduction to the field of statistics. It covers the basic concepts and terminology of statistics, and discusses the importance of statistics in various fields of study. The chapter also introduces the reader to the different types of data and the methods used to collect and analyze them. The chapter concludes with a discussion of the role of statistics in decision-making and the importance of understanding the limitations of statistical inference.

The third chapter of this book is a general introduction to the field of statistics. It covers the basic concepts and terminology of statistics, and discusses the importance of statistics in various fields of study. The chapter also introduces the reader to the different types of data and the methods used to collect and analyze them. The chapter concludes with a discussion of the role of statistics in decision-making and the importance of understanding the limitations of statistical inference.

The fourth chapter of this book is a general introduction to the field of statistics. It covers the basic concepts and terminology of statistics, and discusses the importance of statistics in various fields of study. The chapter also introduces the reader to the different types of data and the methods used to collect and analyze them. The chapter concludes with a discussion of the role of statistics in decision-making and the importance of understanding the limitations of statistical inference.

INTRODUCTION

APPLICATIONS

- Diagnosis and general maintenance of 4 - 20 mA process control loops.
- Troubleshooting of low-to-medium current devices in automobiles, such as lamps, relays, motors and communications lines.
- Detection of leakage current in battery operated devices.
- Monitoring charge current in battery charging systems.
- Testing of low level signal lines in electronic equipment.
- Monitoring serial communications bit streams (RS-232).

Section 2

Specifications

ELECTRICAL

Range / Resolution: (displayed reading)

LOW (200 mA):	0.1 to 199.9 mA dc or rms ac
HIGH (2000 mA):	1 to 1999 mA dc or 1 to 1500 mA rms ac

Accuracy: (% of reading, ± 3 counts for the displayed reading or $\pm 0.15\%$ of range for the analog output.
Meter zeroed prior to measurement in DC or AC-LOW mode.)

dc:	1%
ac low:	2%
ac high (200 Hz- 400 Hz):	4%
ac high (400 Hz- 40 kHz):	2%
ac high (40 kHz - 100 kHz):	3%

Repeatability: 0.5% of reading, ± 3 counts for the displayed reading or $\pm 0.15\%$ of range for the analog output.

Output noise: less than 100 μV rms

Table 2-1 mA-2000 Specifications

Frequency Range: (displayed reading)

dc:	0 Hz
ac low:	10 Hz to 200 Hz
ac high:	200 Hz to 100 kHz

Frequency Range: (analog output)

dc:	0 Hz to 200 Hz
ac low:	0 Hz to 200 Hz
ac high:	200 Hz to 100 kHz

Frequency response: (-3 dB point)

ac low:	400 Hz
ac high:	200 kHz

Rise Time:

ac low:	750 μ s.
ac high:	1 μ s.

Analog output scaling: 1 mV / mA

Analog output load: 10 k Ω min, 100 pF max.

Current • Frequency Limit: 80 A • kHz maximum

Probe Inductance: less than 1 μ H

Temperature coefficient: 0.01% / °C

Table 2-1 mA-2000 Specifications (cont.)

GENERAL

Battery Type:	9 Vdc alkaline (NEDA 1640A) (two required)
Battery Life:	15 hours typical.
Auxiliary Power:	15 to 18 Vdc, 100 mA minimum.
Auxiliary Power Connector:	2.5 mm, center post is positive (+) polarity.
Analog Output Connector:	BNC
Operating temperature range:	0 to +50 °C (+32 to +122 °F)
Storage temperature range:	-25 to +70 °C (-13 to +158 °F)

Table 2-1 mA-2000 Specifications (cont.)

Probe aperture size: 5.3 mm (0.21 in.)

Probe dimensions:

Length: 15.9 cm (6.25 in.)

Diameter: 3.0 cm (1.2 in.)

Meter dimensions:

Length: 13.2 cm (5.2 in.)

Width: 13.5 cm (5.3 in.)

Height: 3.8 cm (1.5 in.)

Weight:

Probe/Cable: 178.6 g (6.3 oz.)

Meter w/batteries: 357.2 g (12.6 oz.)

Shipping: 1.758 kg (3 lb., 14 oz.)

Safety: IEC 1010 Cat.2 (300 volt), Pollution Degree 2

Table 2-1 mA-2000 Specifications (cont.)

Section 3

Operating Instructions

OPERATOR SAFETY



This symbol appears on the instrument and probe. It refers the operator to additional information contained in this instruction manual, also identified by the same symbol.

The following safety rules must be followed during the operation and servicing of the mA-2000. Strict adherence of these rules is essential for safe operation. F.W.Bell Inc. assumes no liability for the failure to comply with these rules.



Do not clamp around conductors with voltages equal to or exceeding 300 V dc or rms ac.

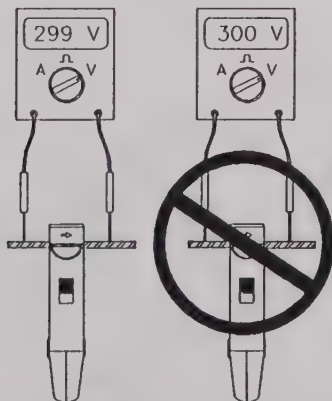


Fig. 3-1
Conductor Voltage Limit Warning

OPERATING INSTRUCTIONS



Do not clamp the probe around bare conductors.

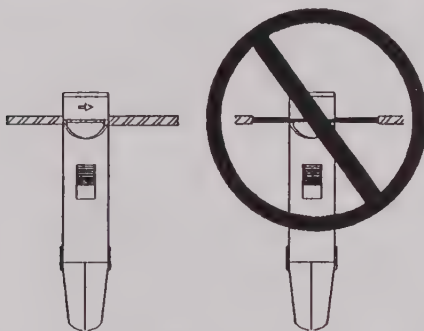


Fig. 3-2
Bare Conductor Warning



Do not connect the auxiliary power connector to an ac power source. Do not exceed 18 Vdc. Do not reverse the polarity.

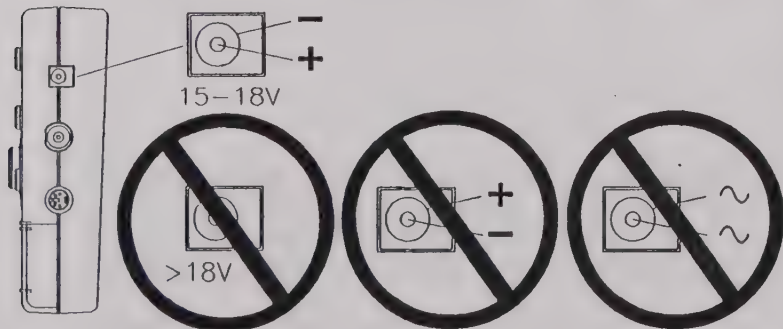


Fig. 3-3
Auxiliary Power Connector Warnings

OPERATING FEATURES

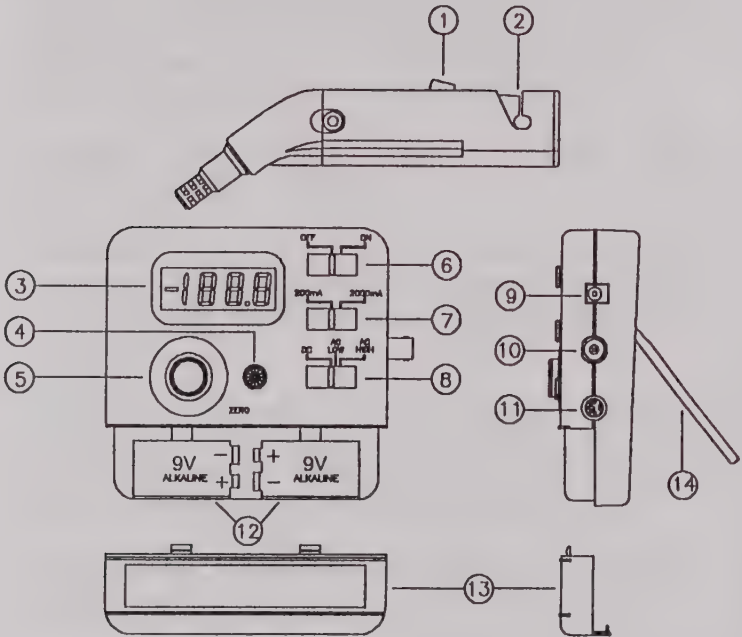


Fig. 3-4
Product Features

- ① **Aperture trigger.** When the trigger is pulled back the aperture ② opens. When the trigger is released the aperture will close slowly. *Do not force the aperture closed by pushing on the trigger or damage may occur.*
- ② **Probe aperture.** The aperture can accommodate up to 5.33 mm (0.21 inch) diameter conductors. The aperture is opened by pulling back on the trigger ①. It is important that the aperture be free of contaminants that

OPERATING INSTRUCTIONS

might prevent the aperture from fully closing, otherwise the earth's magnetic field may affect instrument accuracy. Use only isopropol alcohol and a cotton swab to clean the aperture area. ***Never use a sharp instrument or a stiff brush to clean the aperture or damage will occur !***

- ③ **Display.** LCD containing 3 ½ digits of numeric information and the LOW BAT annunciator.
- ④ **Coarse zero adjust control.** With the aperture closed and no current flowing through the aperture, this control is adjusted so that the displayed reading is as close to zero as possible.
- ⑤ **Fine zero adjust control.** With the aperture closed and no current flowing through the aperture, this control is adjusted so that the displayed reading is zero. If this is not possible readjust the coarse zero control ④ .
- ⑥ **Power switch.** Sliding the switch to the "ON" position turns the meter on.
- ⑦ **Range switch.** The range switch affects the displayed reading only. Sliding the switch to the "200 mA" position results in a measurement range of 0.0 - 199.9 mA. Sliding the switch to the "2000 mA" position results in a measurement range of 0 - 1999 mA. The analog output is not affected by the range switch and always provides an output of 1 mV / mA.
- ⑧ **DC/AC-LOW/AC-HIGH switch.** This three-position switch selects the type of current to be measured. It affects both the displayed reading and the analog output, although differently.

OPERATING INSTRUCTIONS

Sliding the switch to the "DC" position allows for the display of dc current. The analog output will contain both the dc component and any ac component up to frequencies of 200 Hz.

Sliding the switch to the "AC-LOW" position allows for the display of rms ac current in the frequency range of 10 Hz to 200 Hz. The analog output will contain both the dc component and any ac component up to frequencies of 200 Hz.

Sliding the switch to the "AC-HIGH" position allows for the display of rms ac current in the frequency range of 200 Hz to 100 kHz. The analog output will contain any ac component in the same frequency range.

- ⑨ **Auxiliary power connector.** This is an industry-standard, 2.5 mm, dc power connector. The *mA-2000* will accept a dc voltage in the range of 15 - 18 Vdc at 100 mA minimum current. The center pin is positive (+). The internal batteries are disconnected when using this connector.



Do not connect the auxiliary power connector to an ac power source. Do not exceed 18 Vdc. Do not reverse the polarity.

- ⑩ **Analog output connector.** A voltage signal representative of the current being measured is available at this BNC connector. Calibration is set to 1 mV / mA. Minimum load is 10 k Ω .

OPERATING INSTRUCTIONS

- ① **Probe connector.** The clamp-on probe plugs into this connector and locks in place. To disconnect, pull on the body of the plug, *not the cable !*
- ⑫ **Batteries.** Install two 9-V alkaline batteries (NEDA-1640A) in the positions shown. The connections are polarized to prevent accidental battery reversal. It is suggested that *both* batteries be replaced at the same time with new batteries.
- ⑬ **Battery compartment door.** This cover slides off as shown in Figure 3-4.
- ⑭ **Meter stand.** Retractable stand that allows the meter to be viewed when placed on a horizontal surface. A notch in the stand allows the meter to be mounted to a vertical surface.

MEASUREMENT PROCEDURES

Instrument Preparation

1) With the power switch in the "OFF" position, remove the battery compartment door by sliding it off as shown in Figure 3-5. Install two 9V alkaline batteries. Install the battery compartment door.

NOTE: Batteries are not required if using an ac adapter.

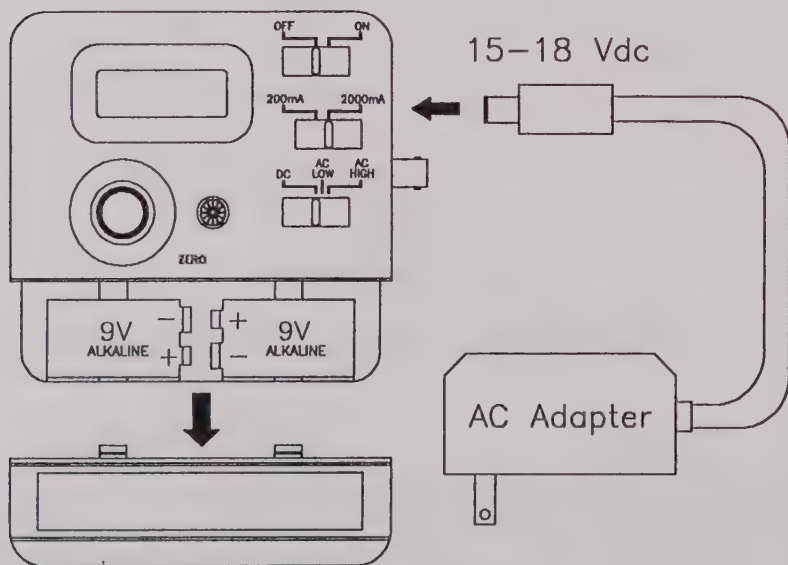


Fig. 3-5
Battery Installation and AC Adapter Connection

2) Connect the probe by matching the keyway on the probe's connector to that of the mating socket in the meter. Push the connector in until it locks in place.

OPERATING INSTRUCTIONS

NOTE: The probe and meter are calibrated together. Probes are not interchangeable. If the probe has to be replaced the meter must be recalibrated with the new probe.

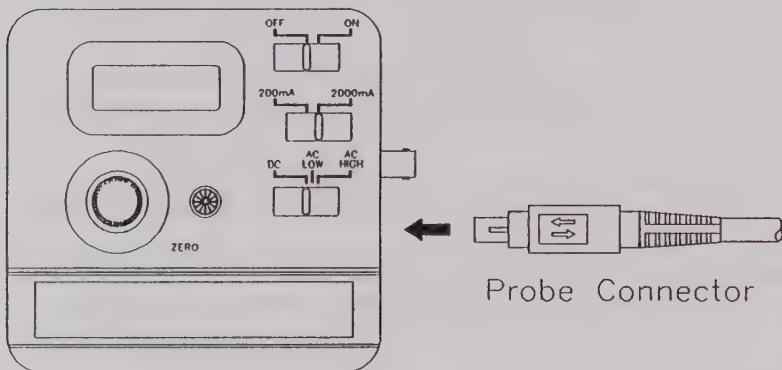


Fig. 3-6
Probe Connection

3) Slide the power switch to the "ON" position and allow the probe to settle for a few seconds.

DC Current Measurements

Initially the probe and meter may contain magnetic and electrical offsets that will be displayed as an actual current reading. This "false" reading must be removed to obtain a true current reading. This process is called "zeroing" and should be performed as follows, referring to Figure 3-7:

- 1) Slide the DC/AC-LOW/AC-HIGH switch to "DC".
- 2) Select the desired range, either "200 mA" or "2000 mA".

OPERATING INSTRUCTIONS

- 3) Open and close the aperture one time. Do not clamp around the conductor to be measured. Stay away from sources of high magnetic fields.
- 4) Using the smaller coarse "zero" knob adjust the reading as close to zero as possible.
- 5) Using the larger fine "zero" knob adjust the reading to zero. Readjust the coarse knob if this is not possible.
- 6) Clamp onto the conductor to be measured and observe the reading. Be sure that the aperture closes fully.

NOTE: When the meter is first turned on the aperture should be opened and closed at least once before zeroing.

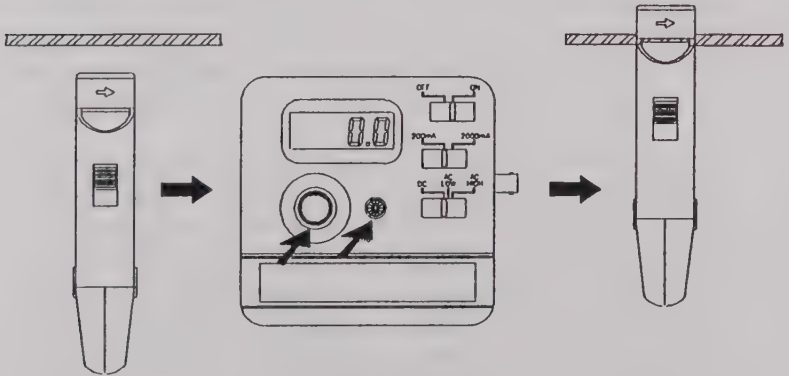


Fig. 3-5
DC Zeroing Process

If the reading appears as a "1 ", the current level exceeds the selected range of the meter. Select the "2000 mA" range and repeat Steps 3-6 above. If already on the "2000 mA" range the current exceeds the measurement range of this instrument.



OPERATING INSTRUCTIONS

An arrow appears on the probe near the aperture. If the reading is positive the current is flowing in the direction of the arrow. If negative the current is flowing in the opposite direction.

A voltmeter or oscilloscope can be connected to the analog output connector. The output is a voltage proportional to the current being measured and is scaled to 1 mV / mA, regardless of the range switch setting. This signal will contain the dc level as well as any ac components up to 200 Hz. The coarse and fine "zero" adjustments also affect the dc level of the analog output.

Low Frequency AC Current Measurements

To measure ac current in the frequency range of 10 Hz to 200 Hz, select the "AC-LOW" setting and select the desired range ("200 mA" or "2000 mA"). Clamp around the conductor. The displayed readings will be the true rms values of the ac current. The coarse and fine "zero" adjustments have no effect on the displayed readings.

A voltmeter or oscilloscope can be connected to the analog output connector. The output is a voltage proportional to the current being measured and is scaled to 1 mV / mA, regardless of the range switch setting. This signal will contain the dc level as well as any ac components up to 200 Hz. Since the coarse and fine "zero" adjustments affect the dc level of the analog output, the meter must be zeroed. This procedure is described in the previous section entitled "DC Current Measurement", Steps 3-6.

High Frequency AC Current Measurements

To measure ac current in the frequency range of 200 Hz to 100 kHz, select the "AC-HIGH" setting and select the desired range ("200 mA" or "2000 mA"). Clamp around the conductor. The

OPERATING INSTRUCTIONS

displayed readings will be the true rms values of the ac current. The coarse and fine "zero" adjustments have no effect on the displayed readings.

A voltmeter or oscilloscope can be connected to the analog output connector. The output is a voltage proportional to the current being measured and is scaled to 1 mV / mA, regardless of the range switch setting. This signal will contain only ac components from 200 Hz to 100 kHz. The coarse and fine "zero" adjustments have no effect on the analog output.



Prolonged operation under conditions in which the product of the current and frequency exceeds 80 A•kHz can cause permanent damage to the probe !

Measurement Hints

- In the "DC" current mode the process of "zeroing" the meter is vital for accurate measurements. The meter should be zeroed *each time* prior to clamping on to the conductor.
 - Check the zero point often. When the meter is first turned on the aperture should be opened and closed at least one time before zeroing.
- In the "DC" current mode sudden large changes in the dc current, or current exceeding the range of the instrument, can induce an offset that will affect the accuracy of the meter, or could cause the meter to overrange. Examples include motor or lamp circuits, where inrush currents far exceed the normal operating current. If this occurs open and close the probe aperture and rezero the meter, or allow the inrush to occur and then clamp the probe around the conductor.



OPERATING INSTRUCTIONS

- The sensitivity of the measurement can be increased by wrapping several turns of the same conductor through the aperture. The turns must be circulating in the same direction. The actual current can be calculated by dividing the reading by the number of turns. For instance, suppose there are 8 turns and the reading is 3.2 mA. The actual current flow is

$$3.2 \text{ mA} / 8 = 0.4 \text{ mA}$$

- It is important that the aperture be free of contaminants that might prevent the aperture from fully closing, otherwise the earth's magnetic field may affect instrument accuracy. This is particularly true in automotive applications where grease and dirt are common elements. Use only isopropyl alcohol and a cotton swab to clean the aperture area. *Never use a sharp instrument or a stiff brush to clean the aperture or damage will occur !*
- If the conductor being measured is too large the aperture will not fully close and the reading will be inaccurate.
- A common mistake made when using clamp-on probes is attempting to measure dual conductors carrying current in opposite directions (i.e. - a lamp cord). Each conductor produces a magnetic field, but the fields oppose one another for a net magnetic field of zero. It is necessary to split the conductor pair and make the measurement on one conductor only.
- When the LO BAT annunciator appears readings may not be accurate. Either use an ac adapter (see the Specifications section for voltage ratings) or replace *both* batteries at the same time. Replacing only one battery will not damage the unit, but will reduce the normal life of the new battery.

OPERATING INSTRUCTIONS

GENERAL MAINTENANCE

- Use only isopropol alcohol and a cotton swab to clean the aperture area. ***Never use a sharp instrument or a stiff brush to clean the aperture or damage will occur !***

WARNING !

The probe is a precision instrument with no servicable parts and no adjustment points. Under no circumstances attempt to disassemble the probe !

- Gently clean the display and case with a soft, dry cloth (do not use chemicals !).
- If the meter is to be idle for an extended period of time, remove the batteries. Battery corrosion can damage the meter.



Regulatory Information

MP MASTER



MA32287

WARRANTY

F.W.BELL INC. warrants each instrument it manufactures to be free of defects in material and workmanship. Our obligation under this warranty is limited to servicing and adjusting any instrument returned to our factory for that purpose, and to replacing any defective parts thereof (excluding batteries). This warranty covers instruments which, within **one year** after delivery to the original purchaser, shall be returned with transportation charges prepaid by the original purchaser, and which upon examination shall disclose to our satisfaction to be defective. If it is determined that the defect has been caused by misuse, abnormal conditions of operation or alteration, repairs will be billed at cost after submitting an estimate to the purchaser.

F.W.BELL INC. reserves the right to make changes in design at any time without incurring any obligation to install same on previously purchased units.

This warranty is expressly in lieu of all other obligations or liabilities on the part of F.W.BELL INC., and F.W.BELL INC. neither assumes nor authorizes any other person to assume for them any other liability in connection with the sales of F.W.BELL INC. instruments.

DAMAGE IN SHIPMENT

The instrument should be examined and tested as soon as it is received. If it does not operate properly, or is damaged in any way, immediately file a claim with the carrier. The claim agent will provide report forms. A copy of the completed form should be forwarded to F.W.BELL INC. We will then make the necessary arrangements for repair or replacement. All correspondence concerning this instrument should include model and serial numbers.

SHIPPING INSTRUCTIONS

Contact F.W.BELL INC. for a Return Material Authorization (RMA) number prior to shipping. All returns must have an RMA number.

Use the original shipping carton and inserts, or surround the instrument with several thick layers of shock-absorbing material and pack it in a sturdy container. F.W.BELL INC. cannot be responsible for damage to the instrument due to improper packaging. Ship to:

F.W.Bell Inc.
Repair Department
6120 Hanging Moss Road
Orlando, Fl. 32807
(407)678-6900

WARRANTY

GENERAL INFORMATION

The following information is provided for your information only. It is not intended to constitute a contract. The actual terms and conditions of the warranty are set forth in the warranty agreement which is provided with the product. The warranty is void if the product is not used in accordance with the instructions. The warranty is void if the product is damaged by accident, misuse, or neglect. The warranty is void if the product is repaired or altered by anyone other than the manufacturer. The warranty is void if the product is used for any purpose other than that intended by the manufacturer.

WARRANTY COVERAGE

The warranty covers the product for a period of one year from the date of purchase. The warranty covers the product for a period of one year from the date of purchase. The warranty covers the product for a period of one year from the date of purchase.

The warranty covers the product for a period of one year from the date of purchase. The warranty covers the product for a period of one year from the date of purchase. The warranty covers the product for a period of one year from the date of purchase. The warranty covers the product for a period of one year from the date of purchase.

For more information, please contact the manufacturer. For more information, please contact the manufacturer. For more information, please contact the manufacturer.

The warranty covers the product for a period of one year from the date of purchase. The warranty covers the product for a period of one year from the date of purchase. The warranty covers the product for a period of one year from the date of purchase. The warranty covers the product for a period of one year from the date of purchase.

The warranty covers the product for a period of one year from the date of purchase. The warranty covers the product for a period of one year from the date of purchase. The warranty covers the product for a period of one year from the date of purchase. The warranty covers the product for a period of one year from the date of purchase.

The warranty covers the product for a period of one year from the date of purchase. The warranty covers the product for a period of one year from the date of purchase. The warranty covers the product for a period of one year from the date of purchase. The warranty covers the product for a period of one year from the date of purchase.